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ABSTRACT

The purpose of this study was to determine the effects of using calculators on the mathematical achievement and attitude of low-income sixth-grade students when they were taught problem solving. Thirty-five sixth-grade students in two intact classes were assigned to two treatment groups. The experimental group was taught problem solving using calculators. The control group was taught using paper-and-pencil. Treatment for both groups lasted eight weeks. The results of this study reveal that there was no significant difference in mathematical achievement gain in problem solving of students who were taught using calculators and those who were not. The students who were not taught using calculators had a significantly better attitude towards problem solving than those who were using calculators. Implications for the classroom and future research were discussed. Appendices included are: (1) the mathematics test and attitude survey including scoring system; (2) instructional plans; (3) "t" calculation; and (4) raw data. (YP)

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# The Effects of Including Calculators in the Problem-solving Instruction for Low-Income Sixth-grade Students

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By

Sarah A. Starr

A Research Project Report

Presented in Fulfillment of the Requirements for the Research Project Course and Field Problem Course in the Graduate Program of Education at Mercer University in Atlanta

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# ABSTRACT

## The Effects of Including Calculators in the Problem-solving Instruction for Low-income Sixth-grade Students

By

Sarah A. Starr

### Purpose

The purpose of this study was to determine the effects on the mathematical achievement and attitude of low-income sixth-grade students when they are taught problem solving using calculators rather than using pencil and paper.

### Methods and Procedures

Thirty-five sixth-grade students in two intact classes were assigned to two treatment groups. The experimental group was taught problem solving using calculators. The control group was taught using paper and pencil. Treatment for both groups lasted eight weeks. The same testing instrument was administered to both groups on the first day as a pretest and on the last day as a

posttest. Data was collected and a *t*-test was utilized to test the difference between the gain scores for the pretest and the posttest ($p<.05$).

## Results

The results of this study reveal that there was no significant difference in mathematical achievement in problem solving of students who were taught using calculators and those who were not. There was a significant difference in mathematical attitude of students who were taught using calculators and those who were not. The students who were not taught using calculators had a significantly better attitude towards problem solving than those who were using calculators.

## Conclusions

The statistical data indicated that higher mathematical achievement or better attitude towards mathematics could not be obtained by teaching students problem solving using calculators. Since this study contradicts most research in the area of attitude, further research is needed to confirm the most effective method of instruction.

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SECTION I

## Introduction

Calculators are everywhere. They are in the homes, schools, and businesses and can now be found built into wrist watches, key chains, wallets, and checkbooks. With a device so accessible to students, why not incorporate it into the curriculum to make it a productive device as well?

In 1974 the National Council of Teachers of Mathematics (NCTM) advised teachers to take advantage of the calculator as a teaching tool (Werner, 1980). Research shows that many teachers have used the calculator as a tool for checking computation and for computation drills, but few teachers have used calculators in the actual teaching process.

In 1976 Werner (1980) listed several areas of basic skills that were lacking and which were identified by the National Council of Supervisors of Mathematics. These areas included applying mathematics to everyday situations, reasonableness of results, estimation, appropriate computation skills, analyzing data, and predicting. All of

these areas are necessary in order to be successful in problem solving. Why are students lacking in the area of problem solving?

The curriculum has been the chief reason for the lack of problem solving-instruction. In the 1950s problem solving was considered very important. In the 1960s "new math" was the main issue. The 1970s brought an increase in problem solving with a swing towards the basic skills. The middle 1980s began the main focus of problem solving. With this increase, students have more practice at becoming better problem solvers (Nibblelink, Stockdale, Hoover, & Mangru, 1987).

Since there has been a change in curriculum due to the increase in problem-solving instruction and the availability of the calculator, some teachers have used calculators to aid them in their teaching of mathematics. Hembree and Dessart (1987) reported that with the calculator less time is spent on computation and more on problem solving. The researchers found that these students also explore areas beyond their grade level. Other researchers discovered that students using calculators were more persistent,

enthusiastic, and more willing to find alternate solutions. If only some teachers found calculators to be so helpful, how did the remaining teachers respond to its integration in the curriculum?

Shumway (1976) and Suydam (1976) reported some negative aspects of calculator usage from teachers of elementary students. The teachers stated the students who used calculators found it unnecessary to learn the basic facts, experienced lower ability for finding errors, and were discouraged to think mathematically. Parents were also opposed to calculator usage in elementary schools. Saxon (1987a) realized that calculators did introduce higher areas of learning at an earlier age, but students were not capable of understanding abstractly at such an early age.

## Problem Statement

The purpose of this study was to answer the following question: Is there a significant difference in mean scores on a problem-solving test and attitude measure for sixth-grade students who are taught problem solving using calculators and those who are not?

## Assumptions

The following assumptions were made prior to conducting the study:

1. The two groups were equivalent in math ability.
2. The measuring instruments were valid and reliable measures of the mathematical achievement level of the students.
3. Daily attendance was stable throughout the study.
4. The students completed all classwork and homework.
5. All calculators functioned properly throughout the study.

## Delimitations

The delimitations for the study were:

1. The study was completed in eight weeks.
2. The study was limited to 38 students divided into two sixth-grade math classes.
3. The study was limited to students in a low socioeconomic area from a suburban public elementary school.

4. The study excluded students who were in Special Education classes which included behavior and learning disorders.
5. The study was limited to two ways of teaching problem solving.
6. The study was limited to two intact sixth-grade mathematics classes.

## Definition of Terms

For the purposes of this study, the following terms are defined.

1. Attitude: "A feeling or emotion toward a fact or state" (Webster, 1973, p. 73). For this study, it will be measured by a teacher-made test (see Appendix A).
2. Basic Skills: Numerical problems with one or more of the four basic operations, addition, subtraction, multiplication, and division.
3. Calculator: "A machine for performing mathematical operations mechanically" (Webster, 1973, p. 156).
4. Computation: " The act of making the calculation" (Webster, 1973, p. 232).

5. Problem Solving: "The process of applying previously learned rules to a situation that is new or different for the learner" (Overholt, Rincon, & Ryan, 1985, p. 1). For this study, it will be measured by a teacher-made test (see Appendix A).
6. Story Problems: "Those mathematical problem situations that are presented orally" (Overholt et al., 1985, p. 1).
7. Word Problems: "Similar, or even the same, problems set forth in written or printed form" (Overholt et al., 1985, p. 1).
8. Verbal Problems: "Either story or word problems" (Overholt et al., 1985, p. 1).

## Summary

The use of calculators in the elementary classroom is still a debatable issue. Manipulative objects, role playing, and group discussions have always aided students in the area of problem solving. This study will determine whether calculators can be added to this list of helpful mathematical tools.

## SECTION II

## PROBLEM SOLVING

### Introduction

According to Adams, Ellis, and Beeson (1977), teachers' greatest problem with students of mathematics is problem solving. Students learn to master computation but not story problems.

What is problem solving? Problem solving is a situation that an individual encounters that has no obvious solution (Rudnick & Krulik, 1976). People of all ages encounter these problematic situations. There are no certain formulas that solve each problem, but there are ways to teach children how to deal with problems in order to be better prepared for life with its abundance of problems.

The goal of every mathematics teacher should be to solve word problems, problems that children will face in the real world. More time is spent on computation drills than on problem solving. The reason for the small amount of time for problem solving varies. Teacher attitudes, curriculum pressures, teaching methods and

techniques, and student capabilities can hinder problem-solving instruction.

## Hindrances

Whether these problems are called verbal problems, story problems, or word problems, anxiety and fear usually follow them in the lives of most students and teachers. Why do students react this way?

Here are two reasons why students dread problem solving.

1. Problem solving requires the use of students' thinking processes. These processes include imagination, association, and abstraction.
2. Problem solving includes creation of original schemes since world problems are not solved using the same processes each time (Adams, Ellis, & Beeson, 1977).

Fennema (1981) added misunderstanding of the problem as a hindrance. She said that most students could not grasp the relationships among the conditions of the problem. The students would just manipulate all numbers given in a problem in an irrational way.

Zweng (1979) mentioned another hindrance found among students. She said that many students lack the problem-solving language. In other words, the students do not comprehend what to do with the information given. They understand the information and can do the computation, but choosing the correct operation using reasoning seemed to be a mystery.

Students are not the only ones hindered when it comes to problem solving. Most teachers dread teaching problem solving. Fennema (1981) found that teachers have the following difficulties.

1. There are no new concepts to teach. The object of the lesson is to get students to use the knowledge already taught to solve any given problem.
2. All students in a classroom have not had the same content taught; therefore, due to the students' diverse backgrounds, teachers are often faced with filling in the gaps for individuals.
3. Some students learn faster than others, especially when learning involves problem solving. While some students are

confident in this area, others require more practice and time.

4. Many problems, especially nonroutine ones, can be solved in more than one way. Teachers can not teach every process to obtain the solution of a problem. They have their style of solving it just as every other person, including students, has his way.
5. The curriculum pressures teachers to emphasize computational skills which leaves less time to teach problem solving.
6. There is a shortage of problems in good sequences of related problems for teachers to use in instruction.

## Techniques

There is not much that teachers can do about some of their hindrances, but there is something that they can do for students to alleviate some of their fears. Bartelo (1983) makes the following recommendations for teachers.

1. Spend more time on the basics of problem solving and the analyzation of problems.

2. Give students a variety of problems to solve.
3. Use calculators to help students become better problem solvers.
4. Allow students to work in teams and make group decisions.
5. Have students bring calculators from home to develop parental involvement.
6. Use small groups for improving problem-solving skills.
7. Make a distinction between computative and thinking skills.
8. Devote at least one third of instructional time to problem solving.
9. Do not hesitate to ask children to think aloud to explain their procedures.
10. Help students relate solving mathematical problems to solving social problems.
11. Do not let problem solving become a mechanical process following a set of rules.
12. Include students in the problems to be solved.

13. Encourage children to write their own problems using their own experiences.
14. Use problems to which the children can relate. A good source to use is the sports page of a newspaper.

Campbell (1984) and Suydam (1982) suggest these additional techniques for problem solving.

1. Have students use physical models to find the solution.
2. Children can learn the language of problem solving by acting out problems and discussing them.

O'Daffer mentions three other helpful ideas.

1. Use a calculator. This alleviates the struggle and error of computation (1987).
2. Work backwards. Some problems can be worked with more understanding if the solver starts with the result and works backwards using inverse operations (1985b).
3. Use puppets and posters with cartoons on them to display word problems. This helps the children relax (1985a).

Overholt, Rincon, and Ryan (1985) have developed eight specific steps to aid students in problem solving. The problem solver:

1. Has to determine what the problem is about.
2. Must read the question to decide what he is looking for.
3. Determines what facts are given that are important in order to solve the problem.
4. Tells verbally how he would solve the problem including the operations he would use.
5. Writes an equation based on step four.
6. Estimates to determine if the solution is reasonable.
7. Solves the equation and compares the answer with the estimation.
8. States the answer in a complete sentence in response to the given question.

Buffington and Wilson (1987) developed a four step problem-solving mode. The problem solver:

1. Reads the problem, determines what is being asked, and identifies the important data.

2. Decides what to do by thinking of similar problems previously solved and uses a variety of stategies.
3. Solves the problem and rechecks each step.
4. Examines his solution for reasonableness.

## Abilities

Certain abilities are necessary in order to be a good problem solver or to teach problem solving. To be a good problem solver Adams, Ellis, and Beeson (1977) report that problem solving requires three basic areas.

1. Intelligence - Problem solving requires a higher level of thinking.
2. Reading - Analytical reading is necesssary to decide what is given and what needs to be done to find the solution.
3. Basic Skills - After deciding how to solve a problem, knowledge of the basic skills is required to do the actual computation.

Buffington and Wilson (1987) provide some additional abilities. They say that good problem solvers should have the ability to:

1. Note likenesses and differences.
2. Identify important and superfluous details.
3. Visualize the problem.
4. Choose helpful procedures using various methods.

Good teachers must also possess certain abilities to be able to teach problem solving. Krulik and Rudnick (1978) lists the following factors. Teachers must:

1. Have a positive attitude towards problem solving.
2. Be able to modify the problem to relate to students' experiences.
3. Use various methods, ideas, questions and allow for discussions.
4. Be enthusiastic and confident.

Buffington and Wilson (1987) list additional requirements for problem-solving teachers. Teachers should:

1. Offer suggestions, give students time to think and solve, and provide a variety of problems.
2. Be questioners. Ask students to compare and explain strategies.
3. Be sources of encouragement and appreciation. They should compliment students, encourage them to find a different solution to the problem, and appreciate the differences.
4. Be role models. Students will be able to detect the teachers' attitudes toward problem solving. Problem solving should be the teachers' top priority and should involve the use of charts, graphs, and manipulatives.

## Empirical Research

According to Nibbelink, Stockdale, Hoover, and Mangru (1987), problem solving has changed in a positive way. From 1950 to 1960 problem solving was emphasized a great deal. With the new math era, from 1960 to 1970, there was little emphasis on problem solving. From 1970 to 1985 an increase in problem solving was very evident. From 1985 to

the present there has been an even bigger increase. Problem solving was no longer something the student did at the end of each chapter or at the end of the year if the teacher had enough time. It now has increased in the amount of problems as well as in complexity.

Along with the increase in problem solving comes the question as to what is the best method of teaching it. What have researchers found to be the best method? Zweng, Turner, and Geraghty (1979) designed a study to determine what helps elementary school children solve verbal problems. The study included third, fourth, fifth, and sixth-grade students. The students were given a 15 item test on their grade level with which they could use manipulatives, drawings, or calculators. They were interviewed by the three researchers. Some of the researchers' findings were as followed:

1. There was no increase across grade levels in solving multi-step problems.
2. Personalizing the problem helped all grade levels.

3. Manipulatives and drawings helped all grade levels.
4. All grade levels were more successful when the numbers in the problems were decreased.
5. None of the hints in one through four above helped any of the students when doing rate problems.
6. The low and average ability students used the calculators more than the high ability group.
7. Fourth graders used the calculator more than any other level.
8. Calculators were used mostly for division problems.

J. Moyer, L. Sowder, J. Threadgill-Sowder, and M. Moyer, (1984) wanted to investigate three different formats of problem solving: drawn, verbal, and telegraphic. The drawn format consisted of drawings mentioned in the problem and labeled with a phrase. The verbal format stated the problem in complete sentences, and the telegraphic format stated the problem in brief verbal phrases. There were 854 students from

grades three to seven in this study. Grade level tests with eight items were given in all three formats. Students took all three tests in two days. The researchers found that there was a significant difference between the means of drawn format and the other two formats at less than .01 level. No significant difference was found between the verbal format and the telegraphic format.

Szetela (1982) conducted a study which consisted of 187 students in grades three to eight. The students were randomly assigned to two groups, an experimental group and control group. The experimental group used calculators while the control group used pencil and paper. Both groups received the same basic instruction in problem solving. Pretests and posttests were administered. The experimental group used calculators on the posttest. Szetela found that there was a significant difference in problem solving between groups using calculators in grades three, seven, and eight and those who did not.

Anthony and Hudgins (1978) wanted to examine the processes fifth graders use to solve problems,

compare the processes of the successful and unsuccessful problem solvers, and develop and administer a program to poor problem solvers to assess its effect. After much screening, 18 students were chosen to participate in the study, nine poor problem solvers and nine better ones. Each student solved problems in the presence of the experimenter. The data collected was used to develop the instructional program for one group of poor problem solvers. After weeks of instruction, this group was tested. The research found that no significant effects occurred for the trained children compared to those who received no training.

C. Wheatley (1980) conducted a study using 44 sixth-grade students. The students were randomly assigned to two groups. The experimental group used calculators and received regular instruction. The control group received only the regular instruction. The experimental group was directed to use calculators for all work assigned. This treatment lasted six weeks. After the study, each student was interviewed and given five problems to solve. The experimental group could use

calculators during the interview. There was no significant difference in the scores between the two groups; however, from observation calculators seemed to have a positive influence on students' problem-solving performance.

Forty-four seventh graders were the subjects of a study conducted by Szetela (1980). He randomly assigned them to two groups, the experimental group using calculators and the control group not using calculators. The treatment lasted three weeks, and the lessons were based on ratio skills and concepts. Pretest and posttests were administered with the experimental group using calculators for problem solving. There was a significant difference in the means of those using calculators and those who did not.

Szetela and Super (1987) conducted a study involving seventh graders in the area of problem solving. There were 42 classes in this year-long study. These classes were divided into three treatment groups. Experimental group I consisted of 14 classes with 290 students who received special instruction in problem-solving strategies using calculators. Experimental group II

consisted of 10 classes with 195 students who received special instruction in problem-solving strategies without the use of calculators. The control group consisted of 18 classes with 338 students who received conventional instruction in problem solving and used no calculators. The teachers of experimental groups I and II attended workshops in which they were instructed on how to teach using the special instruction of problem-solving strategies. Pretests and posttests in achievement and attitude were administered. Experimental group I scored significantly higher than experimental group II and the control group on the attitude tests. Experimental group I also scored significantly higher than experimental group II on the achievement test while experimental group II scored significantly higher than the control group.

Blume and Schoen (1988) wanted to compare 27 eighth-grade students who had received BASIC computer programming, the experimental group, to 27 who had not received any instruction in the area of problem solving, the control group. Each

student was interviewed in a manner in which they were encouraged to think aloud while solving problems in front of the interviewer. The researchers discovered that the experimental group checked for and corrected more errors than the control group: however, there were no significant differences between these two methods of problem solving.

## CALCULATORS

### History of the Calculator

Man's first calculating devices were his fingers. Pebbles and stones were used next. The terms "calculate" and "calculator" come from the Latin root "calcus" which means pebble or stone. In 600 B.C. the Chinese developed the abacus which was the earliest calculating device. In 1614 John Napier introduced logarithms which would do tedious multiplication and division problems more efficiently. William Oughtred invented the slide rule. In 1642 Blaise Pascal invented the first significant digital calculating device which was a gear-driven mechanical adding machine. It was used for centuries. In 1944 Howard Aiken designed

the Automatic Sequence Control Calculator. It served as the prototype for electronic computers. Eckert and Mauchly constructed the Electronic Numerical Integrator and Calculator (ENIAC) in 1946 which contained thousands of vacuum tubes and switches. By the 1950s improvements in electronics led to the replacement of vacuum tubes with transistors. In 1958 Jack Kilby of Texas Instruments invented the integrated circuit which replaced the transistors. From 1960 to 1970 the integrated circuit chip led to mass production of hand calculators (Dickson, 1978).

Research Supporting Calculator Usage in School

Many educators and researchers have their own ideas about whether calculators should be used in the classroom or not. Williams (1987) says students can buy a solar-powered four-function calculator for under five dollars. It is just as easy to have students buy one as part of their school supplies as is pencils and paper. Beakley and Leach (1975) describes its convenience, speed, and accuracy. Due to its speed Blaeuer (1984) names immediate feedback as one of its most important benefits. According to Callahan (1987)

and Yvon (1987) this benefit increases self-confidence and math achievement and develops a positive attitude towards mathematics.

Basic computation is mostly memorization of tables and rules. Most of the teacher's role is in drilling students and making them memorize. Too much time is spent checking the students' work that they can check themselves and not enough time exploring other topics (Teitelbaum, 1978).

O'Neil and Jensen (1982) list a few uses of calculators in the classroom. They are:

1. Understanding place value.
2. Reinforcing students' knowledge of basic facts.
3. Developing an appreciation of the inverse relationships of multiplication, division, addition, and subtraction.
4. Acquiring understanding of commutative, associative, and distributive properties.
5. Practicing estimation skills.

Hembree and Dessart (1987) add that since calculators shorten the amount of time spent with computation, more time can be spent on problem solving. More time could be used to explore areas

beyond the students' grade level. Reys and Reys (1987) found that students using calculators show more persistence in solving problems. Students are more willing to seek alternate solutions. Suydam (1983) discovered that calculators encouraged the use of many strategies to solve a problem.

Some educators and researchers were very specific in how calculators were to be used. Hembree (1986) included drill of basic facts, games, exploration, and checking pencil and paper work. Comstock and Demana (1987) used calculators to teach percentages, rounding, area and perimeter, and exponents. Wiebe (1987) found that calculators aided in teaching integers, mental arithmetic, reasonableness, decimals, and fractions at an earlier age. Chinn, Dean, and Tracewell (1978) said calculators helped in discovering things about numbers not easily revealed with pencil and paper.

Which students benefit from calculator usage? Callahan (1987) recognized that students with physical or mental handicaps score higher, are faster, and attempt more problems when using

calculators. Students with learning disabilities can overcome difficulties in computation. Calculators provide more opportunities for the gifted to explore. Caravella (1977) reported that slow learners gained more confidence when using calculators. Yvon (1987) believed calculators promoted peer cooperation and responsibility in sharing and caring of these devices.

What teacher averages grades with pencil and paper? What adult does long division without a calculator? Calculators are used to balance checkbooks, do income tax, and buy groceries. They have changed the type of math the average person needs to know or uses (Swafford, 1984).

Research Against Calculator Usage in School

With all the benefits of the calculator mentioned earlier, what could possibly be the harm in using it? Bell (1976) did a three-year study based on experience with calculators. He did find a few advantages of using these devices but found more disadvantages among elementary children. The children became frustrated due to the following:

1. Displays have limited number of digits.

2. When decimal answers are involved, the 8-digit display was too accurate for them to understand.
3. All immediate or input data was lost unless recorded by hand.
4. Limited use if battery-operated.

Shumway (1976) and Suydam (1976) added these hindrances:

1. Calculator's ability to disappear due to lack of security at school.
2. Inappropriate for slow learners because there would be no need to learn the basic facts.
3. Reduce children's ability to detect errors since what is punched in is not recorded.
4. Would destroy the basic mathematics curriculum.
5. Paper and pencil skills are still necessary when calculators are not available.
6. Discourages mathematical thinking.
7. Parents are opposed to their use in the classroom.

Coward (1978) and Usiskin (1978) reported that calculators not only discouraged mental arithmetic but could become a crutch to the individual. Students would rely on the machine for even the simplest computation. This is why calculators should not be used until high school.

There have been some studies that showed negative results from students using calculators. Hembree (1986) did a review of 79 studies concerning the effects of calculator use on students' achievement and attitude in grades K-12. Sixteen of these studies were conducted in the fourth grade. The results showed that calculator usage in the fourth grade hindered development of basic skills. Hembree recommended caution to fourth-grade teachers using calculators.

Saxon (1987b) reported that 75% of Japanese students outscored the top 5% of their American peers in mathematic skills. The Japanese concentrate on teaching the basics and do not allow calculators in elementary schools. He believes that teachers in grades K-8 should use their time teaching basic skills needed for geometry, algebra, and trigonometry in high

school, where the calculator would be useful. When calculators are used in elementary schools, advanced concepts and thought processes are taught too early. Children are not capable of understanding abstractly at this age. Finally, he mentions the decline in mental effort, estimation, and reasonableness (Saxon, 1987a).

Rogers (1976) opposes limitations put on calculator usage. He believes that calculators will be successful only if students use them freely.

## Attitudes

### Parents

Parents are always wanting the very best for their children whether it is community opportunities or educational ones. Parents decide who the educational officials will be by voting. They vote for the candidates who believe as they do. Since calculators are in most homes and businesses and within easy access to their children, what is the opinion of parents about calculator usage in the classroom?

Yvon and Downing (1978) conducted a survey asking parents about their feeling concerning

calculator usage in schools. Twelve questions were asked. Schools were chosen from a university-suburb community and an industrial-suburb community. Students from all grade levels took the surveys home to their parents. From the 250 replies the following conclusions were made:

1. No significant differences in responses were found between the two communities.
2. The parents felt that calculators should not be used for grades 3 through 6.
3. There were moderately negative feelings about calculator usage in grades 7 and 8, as opposed to positive feelings about calculator usage in grades 9 through 12.
4. Parents felt that calculators should not be used when doing homework.
5. Parents did agree that calculators could be used along with pencil and paper solutions if teachers monitored.

Teachers

Teachers are rarely asked how they feel about certain trends in education, yet they are the ones

who are responsible for teaching the curriculum given.

Palmer (1978) surveyed all personnel responsible for mathematics instruction in Los Angeles County Schools. Teachers of grades K through 12 were surveyed. Their responses were based on either first-hand involvement and/or opinions. The results of this survey found that teachers:

1. Strongly agree that students will not learn computational skills if calculators are available.
2. Favored having calculators in the classroom since it is a part of our real world.
3. Believe it promotes student motivation, academic achievement, and classroom management.
4. Need workshops to help them incorporate calculators in the curriculum.

Yvon and Downing (1978) also did a survey of teachers at all grade levels. Their replies were divided into groups which were compared by means of a two-tailed t-test at .05 level of

significance. Teachers thought calculators should be part of the curriculum in grades three through six and favored calculator usage for motivation and games. They also did not favor replacing paper and pencil solutions with calculators.

Students

Since education directly involves students, their feelings should certainly be assessed. They have little or no direct input into the curriculum and are therefore guided in instruction regardless of how they feel. When calculators became more readily available, some researchers did decide to tap into the students' emotions. The findings have been astounding which has created some changes in the curriculum.

A ten-question survey by Royce and Shank (1977) was given to seventh, eighth, and ninth-grade science students. Analysis of variance (ANOVA) was used to detect differences among the means of the three groups. No significant difference was found at the .05 level. The students employed the calculator to get immediate feedback rather than waiting for the teacher to check their answers. Most students

found the calculator effective in finding mistakes. They claimed the calculator was a positive reinforcement when their answers were shown to be correct. The researchers found that students, by about 3 to 1, preferred using calculators to check answers over using them for direct problem solving.

More studies on student attitudes concerning calculator usage have been conducted which also included mathematical achievement. These are mentioned in the "Empirical Research" heading of this section.

## Curriculum Change

For the past two decades teaching the basics in mathematics has been the trend. G. Wheatley (1980) said teachers spend most of the school year teaching basic computations and omitted needed topics such as problem solving and application. He stated that the computational oriented curriculum was not necessary and will not prepare students for the future.

Due to the low cost of the calculator, they are found everywhere. They are in the home, office, and in some high schools. Moursund (1985)

said that the only way education in mathematics will progress will be if the system changes from traditional methods to the use of calculators and computers. He questioned why students should learn mathematics using pencil and paper in an environment that included ready access to calculators or computers.

Werner (1980) listed 10 vital areas of basic skills that were lacking as found by the National Council of Supervisors of Mathematics (NCSM) during their 1976 meeting in Atlanta, Georgia. They were:

1. Problem solving;
2. Applications to math in everyday situations;
3. Reasonableness of results;
4. Estimation;
5. Appropriate computational skills;
6. Geometry;
7. Measurement;
8. Analyzing data and constructing tables, charts, and graphs;
9. Predicting; and
10. Computer literacy.

The NCSM believed these areas could be enhanced by using calculators.

In 1974 the National Council of Teachers of Mathematics (NCTM) proposed that since calculators cost less and are available to all students, teachers should take advantage of their potential as teaching tools. The calculator should be used in class for motivation and to reinforce learning (Werner, 1980).

If calculators are integrated into the mathematics curriculum, what changes need to be made? For junior high and high schools, Higgins (1974) suggested less computation, more problem solving, computer programming, and basic statistics.

Saunders (1980) believed mathematics should be geared towards getting students prepared for a career. He interviewed people from 100 different occupations. In his findings 98% of the occupations interviewed used calculators. Over 15% of the jobs used more math than required in school. If calculators are used, less time would be spent on teaching computational skills and more time would be available to teach higher

mathematics. Approximately 65% of the occupations used statistics. He concluded that educators needed to stay in touch with occupational requirements in order to decide what should be included in the mathematics curriculum.

Another change that needs to be made in the mathematics curriculum is in the area of testing. Carpenter, Corbitt, Kepner, Linquist, and Reys (1981) gave two groups of students a timed mathematics test. One group used calculators after a very brief orientation on how to use them. The other group used pencil and paper. The calculator group took longer to take the test due to unfamiliarity of the calculator, lack of self-confidence, and inability to interpret results on the calculator display. The most significant result of the test was found in the area of problem solving. The tests showed that students with the calculator did no better than the pencil and paper group. This proves that calculators can not solve problems. It requires thinking, organization, and the development of how to solve it before the calculator can be effective. For this reason McAloon and Robinson

(1987) believed that before calculators could be used on tests, a few steps would have to take place.

1. Students in all grades should have unrestricted use of the calculator.
2. A calculator-integrated curriculum must be developed for grades 1-8 which included problem solving.
3. Calculators should be used in all testing situations except when testing acquisition of basic skills.

They did concede that some textbook companies were incorporating calculators in their curriculum, but until a calculator-integrated curriculum was developed, computational skills would continue to be empnasized over problem-solving skills.

## Empirical Research

Suydam (1984) reported that the majority of pupils enjoy mathematics. In fact one-third of all students ranked mathematics as their favorite subject. Suydam found very few differences between elementary boys' and girls' attitudes toward mathematics. She said that this positive attitude towards mathematics remained constant

until the sixth grade. Then it seemed to become less positive as students progressed in school. She also stated that there was a small relationship found between students' achievement and attitudes in mathematics. She continued by saying that there was limited evidence found that teachers' attitudes toward mathematics affected pupils' attitudes toward mathematics.

What can teachers do to improve students' attitudes toward mathematics? Suydam (1984) had found the following in her research. Teachers should:

1. Show that they enjoy mathematics.
2. Show that mathematics is useful.
3. Include students' interests in instruction.
4. Provide experiences designed to help children be successful.
5. Make mathematics enjoyable.

One way many researchers have found to make mathematics more enjoyable is to include the use of calculators. Suydam (1979; 1983) reported that over 100 studies have been conducted concerning calculator usage, at least 75 of which explored

the idea of whether calculators increased achievement. According to Shumway et al. (1981), most of these studies were invalid due to serious design and sampling problems.

The following studies were conducted in kindergarten through ninth-grade classrooms across the United States. Some investigate the use of calculators in increasing mathematical achievement while others explore the use of calculators in that area and in improving attitudes toward mathematics.

Behr and Wheeler (1981) randomly selected 30 kindergarten and first-grade students to test whether they could use calculators as counting tools while:

1. Counting orally;
2. Using the manipulation of a set of objects; and
3. Using another calculator to tally.

The researchers also wanted to see if the calculator worked as well as any other method. The data collected suggested that most kindergarten and first-grade children, when using a calculator, were able to maintain a one-to-one

correspondence between successive punches of the counter button and an oral count. Most of these students were also able to use the calculator as a counting tool successfully while moving objects one at a time.

Four experiments using calculators were designed for children in kindergarten through second-grade by J. Scandura, G. Lowerre, A. Scandura, and J. Veneski (1978). The first experiment involved first graders in 15 lessons in mathematics of about 20 minutes each. The students were divided into two groups. One group worked with calculators while the other group used manipulatives. The researchers observed that the calculator group:

1. Were highly enthusiastic.
2. Benefitted the easily distracted children by providing something to do with their hands.
3. Extended their concentration span.
4. Promoted independence when working.
5. Explored other symbols on the calculator.
6. Created their own problems and used larger numbers.

7. Quickened their pace in solving problems. The group without the calculators were uncreative, disliked the manipulatives, were jealous of the calculator group, were unmotivated, worked slowly, and did not seem to achieve as much as the other group.

The second experiment was very similar to the first study except this one involved kindergarten children in readiness activities. The students had over 30 lessons of instruction. The results were basically the same as the first experiment.

Second graders were used in the third study. The lesson involved problem solving and consisted of eight sessions of 20-25 minutes each. Again, the calculator group was highly motivated while the no calculator group seemed to lose interest.

The final study involved randomly assigned kindergarten students to two groups. The researchers wanted to determine the effects of open ended exploration with the calculator versus specific instruction of its use. The discovery group was given a calculator to manipulate on their own unless they specifically asked for help. The control group was taught the basic functions

of the calculator. There were eight lessons covering the same topics with only the amount of instruction being different. Again, the results were the same as the other three studies. The researchers discovered that the children need to explore independently for the first few sessions, then receive instruction for the remaining time as necessary. Finally, calculators are not to replace drill and practice nor should they be used only to check hand calculations.

McNicol (1985) conducted a study that had two main objectives. She wanted to know if calculators would change the students' attitudes toward mathematics and aid the students in problem solving. The main study had 30 third graders, 17 boys and 13 girls, and lasted nine months. The students were administered an attitudinal scale and asked to write one word problem at the beginning of the study. Six out of 30 students were selected to be interviewed and videotaped six times throughtout the study while writing and solving problems with various manipulatives. After nine months, the students were administered a posttest which was a standardized test and an

attitudinal scale. No significant differences were found. The researcher concluded that calculators should be used as manipulative tools.

Standifer and Maples (1981) randomly assigned nine third-grade students to three groups. The control group (n=64) received regular instruction in mathematics. Experimental group I (n=77) used calculators with regular instruction, and experimental group II (n=82) used programmed-feedback calculators with regular instruction. All groups were pretested in basic mathematical achievement and attitude. After 11 weeks of instruction, posttests were administered, and calculators were removed from the classroom. Four weeks after the posttests, retention tests were given. The scores from the posttests and retention tests were analyzed through analysis of covariance (ANCOVA). Both tests showed significant differences among the groups in the acquisition of computational skill ($F=11.08$, $p<.001$) and in total mathematical achievement ($F=4.34$, $p<.014$). At the .05 level experimental group I was far superior to experimental group II and the control group in computational skill and

in total mathematical achievement. There were no significant differences among the groups in conceptual skill or in attitudes toward mathematics.

G. Lowerre, A. Scandura, J. Scandura, and J. Veneski (1978), who in 1974 did four mini-experiments with K-2 grade students, decided to do a sequel with third and fourth-grade students. This experiment was to determine which standard mathematics topics could be taught more effectively using calculators, how calculators could enhance problem solving, and which new mathematical topics could be introduced using calculators. Five third and fourth-grade students were tested. Instruction took place during 32 class meetings for 10 weeks, with each meeting lasting 30 to 60 minutes. A pretest and posttest were given. Many topics were covered due to the limitation of having a small group. The results of this study were as follows:

1. The standard mathematical topics that could be taught to this group using calculators were place value skills, decimals, negative numbers, metric

measures, and prime and composite numbers.

2. For problem solving the students were able to deal with real life situations involving larger numbers and multiple operations.
3. The new mathematical topics that could be introduced at an earlier age were computation using larger numbers, noting number patterns, and practicing addition and multiplication facts.

Schafer, Bell, and Crown (1975) conducted a study using five intact fifth-grade classes where the students were predominantly from middle and upper-middle-class families. The researchers wanted to determine whether students who took tests using calculators would perform better than those who do not use calculators. Three classes (n=70) served as the experimental group, and the other two classes (n=50) served as the control group. All pupils were given the Mathematics Computation Test (Form A) as their pretest. The instruction lasted for about 3 months with the control group using only paper and pencil and the experimental group using calculators only for a

couple of weeks prior to the posttest. Both groups were given a posttest (Form B of the pretest). The experimental group was allowed to use calculators on the test. The scores showed that there was no significant difference in mathematical achievement between the students using calculators on the test and those who did not.

Wheatley et al. (1979) wanted to explore the effects of calculators in knowledge of basic facts, computational skill, and understanding the results of calculator use. They also wanted to detect any motivational effects of calculators. The design included a school in each of the states of Indiana, Iowa, Michigan, Missouri, and Ohio. In each of these schools two classes at each grade level, 2 through 6, were randomly assigned to the experimental group which used the calculator or to the control group which did not use the calculator. There were 1500 students, 50 teachers, and five schools involved in this study. All students were pretested in mathematical achievement and attitude. All teachers involved in this study participated in a two-hour

calculator workshop. The calculators were used 30% of the classroom time. After 14 weeks of instruction, tests were administered. Then the calculators were removed from the experimental group and given to the control group. After 14 more weeks posttests were given. Basically, there was no significant difference in mathematical achievement or attitude. Shumway et al. (1981) did find one area of significance. The scores of the calculator group showed strength in the Special Topics section where $p<.091$. These researchers believed that this was due to the area of negative numbers.

West (1980) designed a study using 90 fourth, fifth, and sixth graders. They were randomly assigned to three treatment groups. Experimental group I (n=30) received regular instruction plus extra drill with electronic calculators while experimental group II (n=29) received regular instruction with extra paper and pencil drill. The control group (n=31) received only regular mathematical instruction. Pretests were administered with two weeks of instruction following. Then posttests were given. The tests

were two-fold. One part called the "Tables" test was a timed four-minute test which consisted of 100 multiplication facts with factors 7, 8, and 9. The other part was called the "Transfer" test. It was a timed six-minute test of multiplication problems where a three digit number is multiplied by either 7, 8, or 9. T-tests were used to determine which of the posttest means of experimental group I and experimental group II differed significantly from the control group. Only experimental group II showed a significant difference at the .01 level on the "Tables" test. Experimental groups I and II showed a significant difference on both the "Tables" and "Transfer" tests. Since experimental group II (paper and pencil only) performed better than the other two on the "Tables" test, the researcher states the pencil and paper was better in multiplication drills than the calculator. West said that the results might have been different if instruction had covered a longer span than two weeks.

Nelson (1976) designed a study for the purpose of evaluating the effect of using a hand calculator in improving basic computation skills

and attitudes toward mathematics among 196 fourth, fifth, sixth, and seventh-grade students. Four intact classes served as four separate groups. The control group received regular mathematical instruction for 12 weeks. Experimental group I used calculator-involved curriculum for their total mathematical program. Experimental group II used a diagnosis-remediation calculator program only. Experimental group III received the regular mathematical instruction plus had access to calculators. Pretests and posttests were administered to all four groups. The ANCOVA statistic was used to compare the mean gain achievement scores of all groups. Nelson drew the following conclusions.

1. Gains in basic computational skills and attitudes were significantly improved at .01 level using hand calculators.
2. Planned use of calculators in the curriculum improves computational skills and attitudes at .01 level.
3. No significant differences were found among the three experimental groups in achievement.

Jones (1976) used a group of 171 sixth-grade students to investigate the effects of using hand-held calculators on mathematical achievement, attitudes, and self-concept. He randomly assigned six intact classes. The experimental group used calculators and the control group used paper and pencil. The treatment lasted for nine weeks. The students were given a pretest and posttest. The experimental group was not allowed to use calculators during the tests. The results indicated that the experimental group showed significant gains at the .001 level in computation, concepts, and total mathematical achievement. No significant differences were found in attitudes of students toward mathematics.

A study by Sullivan (1976) consisted of two sixth-grade classes. To insure no loss in computational skills, calculators were used during lessons but not on tests or at home. The researcher reported high levels of interest in calculator use which remained throughout the year. He observed that the calculator encouraged students to explore topics not usually covered in

the sixth grade and increased interest in the relationship of fractions to decimals.

Leechford and Rice (1982) wanted to determine whether a specifically designed curriculum would be better than supplementing the regular program. They randomly assigned 33 sixth-grade students to two groups. Group I was instructed using the specified curriculum in which each lesson the students solved problems by using mental estimation, selected hand computation, and hand-held calculator activities. Group II received regular instruction with supplementary material. A pretest was given which measured achievement in computation and problem solving. The lessons lasted several weeks. At the end of the project students were posttested. Group I could use calculators on the posttest. A significant difference in the use of hand-held calculators with a specifically designed curriculum did have an effect on student achievement in computation. Analysis of data by Fisher's "t" for testing differences of independent means was used. A significant difference was found in problem solving with the

use of the calculator. The calculator instruction allowed students to spend more time on problem solving situations due to less time on computations. No evidence was found that students lost skills in computation by using calculators.

Jamski (1979) designed a study consisting of 136 sixth, seventh, and eighth-grade students. This study was to determine the effect on mathematical achievement of learning specific conversion algorithms with calculators. The students were randomly assigned to three classes using the calculator, the experimental group, and three classes not using the calculator, the control group. Each group was also divided into subgroups according to mathematical ability. All students received instruction from the same teacher while the researcher observed. A pretest was administered to both groups followed by four weeks of instruction. The posttest was given to both groups with the experimental group using calculators while the control group used only pencil and paper. One month later the posttest was given again where neither group used calculators. ANOVA was used to determine any

significant differences. The conversion of fractions to decimals was the only one that was significantly different due to the treatment. There were no significant differences in achievement found in the retesting.

Rudnick and Krulik (1976) included 600 seventh-grade students in their study which lasted one year. This study was designed to measure the effect of the availability and use of calculators on students' total mathematical achievement and their ability to perform basic skills using paper and pencil. The students were randomly assigned to the experimental group (unlimited use of calculator) and the control group (regular instruction). Both groups were pretested on attitudes toward mathematics and mathematical achievement. Students were not allowed to use calculators during tests. The experimental group performed better than the control group. Parental surveys were sent home at the end of the treatment to get their opinion. 60% of the parents returned their surveys and responded as followed:

1. 51% - Calculators hindered child's performance.

2. 55% - Calculators improved attitudes towards mathematics.
3. 48% - The child becomes dependent on calculators for basic skills.
4. 49% - Calculators should be permitted in seventh grade.
5. 78% - The child should receive instruction on calculator use.

Achievement and attitude was also the focus of Creswell and Vaughn (1979). Seventy-one ninth-grade students were randomly assigned to two groups, the experimental group (n=33) and the control group (n=38). The experimental group received a special curriculum which integrated calculator usage. The control group received regular instruction. Pretests were given followed by eight weeks of instruction. Then the posttest was administered. Multiple regression analysis on pretest - posttest data showed there was a significant difference at .05 level in favor of the experimental group. There was no significant difference between the experimental group and the control group in attitudes toward mathematics.

Cech (1972) also designed a study determining the effects of calculators on attitude and mathematical achievement. Cech's study differed from Creswell and Vaughn (1979) in that Cech's seven-week study involved only low achievers. Approximately 100 students were randomly assigned to two groups. The experimental group received regular instruction plus used calculators to verify their pencil and paper calculations. The control group had to check their own calculations. Both groups received a pretest and posttest measuring mathematical achievement and attitude. Using t-tests to compare the pretest - posttest data indicated significant gains in achievement and attitudes. Also, calculators reduced disruptive behavior.

Hutton (1976) basically performed the same study as Cech (1972) except she used average-ability ninth-graders. She randomly assigned 10 intact classes in Indiana to three groups. The control group received regular instruction. Experimental group I received regular instruction integrated with calculator lessons. Experimental group II received regular

instruction plus had calculators available with no lessons using it. Pretests were administered to measure attitude and achievement. After the treatment, posttests were given. Using the t-test to analyze means of the three groups at .05 level, Hutton found no significant difference in attitude or in achievement.

## Summary

Much research has been conducted concerning calculator usage, especially in secondary grades. The research available for the elementary grades encompasses calculator usage in computation and attitudinal change. There is less research in problem solving. The research in problem solving utilizes the calculator more as a tool to check computation. More research is needed in using calculators as a teaching tool.

# SECTION III

# METHODOLOGY

## Overview of the Study

This chapter describes the methods used in this research study. The hypotheses are stated and the instrumentation is described. The sampling technique, experimental design, and statistical analysis of the research study are also described.

## Statement of the Hypotheses

This study is designed to test the following null hypothesis at the .05 alpha level of significance. There is no significant difference in mathematical problem solving and in attitudes toward mathematics for low-income sixth-grade children who are taught using calculators and those who are not. The research hypothesis is the following. There is a significant difference in mathematical problem solving and in attitudes toward mathematics for low-income sixth-grade children who are taught using calculators and those who are not.

## Instrumentation

In this study a teacher-designed test was given to the experimental and control groups as a pretest and posttest. The test consisted of 10 problems to solve, 13 statements to be rated according to students' attitudes toward mathematics, and 5 personal questions. The 10 problems included decimals, fractions, and whole numbers in story problems, comparisons, measurement, and geometry. The 13 statements were rated never, sometimes, or frequently as to how the students felt in that area of mathematics. The 5 personal questions aided the researcher in collecting demographic data for this study and were included in the pretest only.

See Appendix A for copies of the test and survey. Tests were evaluated according to standards established by McAloon and Robinson (1988).

## Sampling Technique

The subjects for this study were 35 sixth-grade students from a lower socioeconomic background. The sample contained 17 girls and 18 boys. Twenty-one students came from one-parent

homes, while the remainder lived with two parents. The sample consists of 21 whites and 14 blacks. 34% received either free or reduced lunch rates.

The academic levels of these students vary slightly. The majority are on grade level.

The 35 students were randomly assigned to two classes at the beginning of the year according to reading level. Both classes contain about the same number of students in each of the three levels of reading. Each class has a group below sixth-grade reading level, on grade level, and above grade level. Since the classes were so similar in math and reading abilities, they were left intact for this study. The experimental class had 19 students and received the treatment. The other class was the control group which had 16 students.

The experimental and control groups were given the same pretest. The experimental group received instruction which incorporated the calculator. The control group received the same instruction but used only pencil and paper. Both groups received this type of instruction for eight weeks and were given the same posttest at the end

of the treatment. The gain scores were used to compare the two methods of instruction.

## Experimental Design

The design in this study was a Nonrandomized Pretest-Posttest Control Group Design. The design is shown in Table 1.

Table 1

Nonrandomized Pretest-Posttest Control Group Design

| Assignment | Group | N | Pretest | Variable | Posttest |
|---|---|---|---|---|---|
| D | E | 19 | $X_1, A_1$ | T | $X_2, A_2$ |
| D | C | 16 | $X_1, A_1$ | P | $X_2, A_2$ |

N: Number of subjects in sample

D: Nonrandomized assignment

E: Experimental group

C: Control group

T: A teaching method using calculator

P: A teaching method using pencil and paper

$X_1$: Pretest to measure any knowledge of subject area

$X_2$: Posttest to measure gain in knowledge of subject area.

$A_1$: Pretest to identify attitude toward subject

$A_2$: Posttest to identify any change in attitude toward subject

Procedures

The experimental and control groups in this study received treatment for eight weeks during the winter quarter. Each class met for 45 to 50 minutes. Both groups were given the pretest which included the demographic survey (see Appendix A). Since both groups were intact classes and had the same instructor, the researcher, they met at different times. The control group received their instruction first. The experimental group received theirs 45 minutes later. The experimental group used solar calculators, one for each student. They used the calculators in checking new material learned in class, homework, creating new problems to solve, experimenting, and exploring. The experimental group never used them on their tests. The control group used pencil and paper only and had the same homework assignments as the experimental group. The areas covered

during the eight-week period were decimals (division, multiplication, subtraction, and addition), changing fractions to decimals, percentages, finding the least common multiple and greatest common factor, fractions (find lowest terms, equal fractions, and changing mixed numbers to improper fractions, and changing improper fractions to mixed numbers), and geometry (perimeter, area, and volume). (see Appendix B). Both groups were given a posttest.

Statistical Analysis Procedure

To test the hypothesis formulated for this study, gain scores from both pretests and posttests were collected from the control and experimental groups. Data were analyzed by using a two-tailed *t*-test. The level of significance was preset at .05.

## SECTION IV

## RESULTS

### Summary

There were 38 students who participated in an eight-week study comparing two methods of teaching. There were 17 students in the control group and 21 students in the experimental group. By the end of the study, there were 16 students in the control group and 19 in the experimental group because three students moved within that time. Both groups were administered a ten-item problem-solving pretest and an attitude survey on the same day. The control group received regular mathematical instruction and used pencil and paper. The experimental group received the same instruction but incorporated the calculator in the instruction process. Both groups took the posttest at the end of the eight-week period. The total gain scores for the control group in mathematical achievement were 160 for 16 students with a mean gain score of 10. The total gain scores for the experimental group in mathematical achievement were 192 for 19 students with a mean gain score of 10.105. The total gain scores for

the control group in attitude were 15 for 16 students with a mean score of .9375. The total gain scores for the experimental group in attitude were -31 for 19 students with a mean gain score of -1.63. A t-test was done to compare the gain scores in achievement and attitude. A summary of the statistical results in achievement is presented in Table 2. A summary of the statistical results in attitude is presented in Table 3. The detailed statistical computations are found in Appendix C.

Table 2

t-Test Results in Achievement

| Group | N | $\overline{X}$ | s | t |
|---|---|---|---|---|
| E | 19 | 10.105 | 8.704 | .0371 |
| C | 16 | 10 | 7.92 | |

Table 3

t-Test Results in Attitude

| Group | N | $\overline{X}$ | s | t |
|---|---|---|---|---|
| E | 19 | -1.63 | 3.06 | 2.3953 |
| C | 21 | .9375 | 3.2755 | |

The acceptance of the null hypothesis in achievement was determined at the .05 level of significance with 33 degrees of freedom. The calculated t of .0371 was less than the critical t of 2.035. Therefore, the null hypothesis of achievement was accepted.

The rejection of the null hypotheses in attitude was determined at the .05 level of significance with 33 degrees of freedom. The calculated t of 2.3953 was greater than the critical t of 2.035. Therefore, the null hypothesis of attitude was rejected.

## Conclusions

There was no significant difference in mathematical achievement of students who used calculators in problem solving and students who

used pencil and paper. The results indicated that the calculator did not help the students score higher when doing problem solving.

There was a significant difference in attitude towards mathematics of students who used calculators in problem solving and students who used pencil and paper. The results indicated that the calculators did not improve the students' attitudes toward mathematics compared to the students who used pencil and paper only.

Limitations

This study had the following limitations:

1. Time of study was limited to eight weeks.
2. CRT testing interrupted this study for one and a half weeks.
3. Three students moved during the study.
4. The flu epidemic occurred during the study with seven students missing at least one week of school.
5. Calculators were not used by the experimental group everyday due to the wide range of mathematical topics that were covered.

6. Not all students completed homework assigned.

## Discussion

The experimental group was very excited about using calculators. The enthusiasm dwindled as they progressed throughout the weeks of this study. Some of them spent most of their time just pushing buttons. They had to be told to put the calculators aside in order to get their attention.

The highest possible score for the attitude survey test was 39 with 13 being the lowest. Out of the 35 students in the study, 21 resulted in negative gain scores and two showed no gain at all. Fourteen of these negative gain scores and the two gain scores of zero were in the experimental group.

Why did the experimental group regress in attitude? In the attitude pretest survey the researcher discovered that the average number of calculators in each student's home was three. If students have that many calculators available to them, the novelty of using them at school will not last.

The experimental group also did less work on the board because they were using calculators to check their work as well as learn new lessons. Since they were going to the board less, competition between peers lessened. Their pride, self-confidence, and reassurance lessened as well.

The one and a half weeks used for CRT testing prior to the end of this study could have changed the experimental group's attitude. During this time they were not allowed to use a calculator. They may have felt cheated by having their "toy" taken away from them temporarily.

No students made a perfect score (50) on the posttest in mathematical achievement; however, one student made a 48 which means he missed one-half of a problem. Students who showed no work but had the correct answer did not get full credit for it; therefore, the researcher encouraged the students to show all of their work. The ten-item test in achievement was worth five points per item for a total of 50. The posttest results are in Appendix D.

In the area of achievement the control and experimental groups were basically the same. Only

one student from each group had a negative gain score. One of these was absent for three weeks during this study. Since there were so many topics covered during this study, the gain scores were low. The high standard deviation reflects the wide range of mathematical and reading abilities.

Implications for the Classroom

Although the study did not indicate higher scores using the calculator, the students seemed to enjoy using the calculators. It promoted enthusiasm and was very useful in the area of decimals with its quick computations. It also aided in checking students' work but did not show why the student missed a particular problem. Very few students mentioned that they enjoyed using the calculator. The researcher suggests using the calculator in the classroom for motivational activities and sparingly, if at all, in the teaching process. Its use in the teaching process seems to promote negative attitudes toward mathematics.

## Implications for Future Research

The researcher found studies that reported no significant difference in achievement between students who used calculators and those who did not. These studies included Wheatley et al. (1979) and Hutton (1976). However, the researcher found no studies that reported better attitudes in students who did not use calculators rather than those who did.

The results of this study contradict every study known to the researcher in the area of attitudes. Standifer and Maples (1981), Wheatley et al. (1979), Jones (1976), Creswell and Vaughn (1979), and Hutton (1976) found no significant difference in attitude towards mathematics between students who used calculators and students who did not. In fact Nelson (1976) and Cech (1972) found that better attitudes resulted in calculator usage.

Could it be that only the older studies, Nelson (1976) and Cech (1972), found significant differences in attitudes of students in favor of the calculator because the calculator was a new invention? Did it make a difference because it

was new to the teachers as well as the students? Then as the years progressed, studies began to show no significant differences in attitudes toward mathematics between students who used calculators and those who did not. Finally, this study shows adverse effects in attitudes toward mathematics due to calculator usage.

Has the role of the calculator changed again? Does the calculator need to be removed from the elementary classroom? Would the results have been the same if the study was much longer than eight weeks? Since the experimental group did not use calculators on the posttest, did this affect their posttest results? Would they have performed better than the control group? The researcher sees a great need for more research in this area to see if the results of this study reflect the attitude of all students today.

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APPENDIX A

MATH PRETEST/POSTTEST

ATTITUDE SURVEY

I have found these measuring instruments to be valid and reliable measures of the mathematical achievement level of these students.

Sarah Ann Stein

Signature of Researcher

Linda Anderson

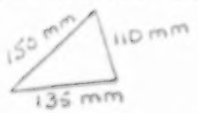
Mathematics Teacher

Grade 6 Pretest/Posttest

Name_____ Date_____

Read each problem carefully and solve it. Show ALL work.

1. A sailing ship is 15 meters wide. The length is 7.63 times the width. How long is the ship?
2. A fishing ship caught 12.9 tons of fish in 4.3 hours. What was the average catch per hour?
3. Write 15/8 as a decimal.
4. The runner in the race ran 5613 meters. How many kilometers is this?
5. Find the perimeter of this figure.




6. Three out of every 4 chickens on John's farm are white. There are 24 chickens on the farm. How many are white?
7. Write <, >, or =. 7/12 2/9
8. The recipe calls for 5 1/2 cups of flour. How many half cups are there?
9. A student worked on his homework 1 1/2 hours on Wednesday, 3/4 of an hour on Thursday, and

2 2/3 hours on Friday. How much time did he spend doing his homework in all?

10. A tri-colored rope is 20 feet long. The red part is 8 1/3 feet long, and the yellow part is 7 1/2 feet long. How long is the green part?

STUDENT SURVEY

Circle the best answer.

1. One of my favorite subjects is math.

   Never Sometimes Frequently

2. I make good grades in math.

   Never Sometimes Frequently

3. I like coming to math class.

   Never Sometimes Frequently

4. My math class is fun.

   Never Sometimes Frequently

5. I am happy when I am in math class.

   Never Sometimes Frequently

6. I like having homework in math.

   Never Sometimes Frequently

7. I like the way we check our math homework.

   Never Sometimes Frequently

8. I can ask questions in class.

   Never Sometimes Frequently

9. My math teacher answers my questions.

   Never Sometimes Frequently

10. I like our math textbook.

    Never Sometimes Frequently

11. I enjoy the classwork that is assigned.

    Never Sometimes Frequently

12. I like the way the math lesson is taught.

    Never  Sometimes  Frequently

13. I understand the math lesson after it is taught.

    Never  Sometimes  Frequently

---

(This section appears on the pretest survey only.)

14. I live with:

    Mom & Dad  Mom & Step-Dad  Step-Mom & Dad

    Dad  Mom  Other_____

15. I live in a(n):

    apartment  house  trailer  condominium

    other_____

16. For lunch I do the following each day:

    pay $.75  pay $.20  bring lunch  it is free

17. How many calculators are in your home?

    0  1  2  3  4 or more

18. I am:

    a boy.  a girl.

Scoring System for Pretest - Posttest

Developed by McAloon and Robinson

| Number of Points | Observed Characteristics |
|---|---|
| 0 | - Blank paper |
| | - No understanding of problem evident |
| | - Incorrect answer and no work shown |
| 1 | - Inappropriate strategy started--problem not finished |
| | - Unsuccessful approach, did not try another |
| | - Attempt failed to reach a subgoal |
| 2 | - Inappropriate strategy--showed some understanding |
| | - Appropriate strategy used--found no solution or reached a subgoal but did not finish the problem |
| | - Correct answer--no work shown |
| 3 | - Appropriate stategy but--ignored a condition in |

the problem, incorrect answer for no apparent reason, or thinking process unclear

4 - Appropriate strategy used
- Work reflects understanding of the problem
- Incorrect answer due to copying or computational error

5 - Appropriate strategy
- Work reflects understanding of the problem
- Correct answer

APPENDIX B

LESSON PLANS

## Dividing Decimals

OBJECTIVE: To divide a decimal by a decimal.

MATERIALS: Harcourt Brace Jovanovich (HBJ) textbook, HBJ Practice Worksheet (p. 57), and calculators.

PROCEDURES:

1. Explain that all numbers must by divided by whole numbers. Give examples. If the divisor is a decimal, it must by changed to a whole number. Whatever is done to make the divisor a whole number must be done to the dividend. This can also be explained by writing equal fractions. Whatever is done to the numerator must also be done to the denominator.
2. Write the following on the board.

   14 / 2  140 / 20  1400 / 200

   Have students solve these problems on their calculators.
3. Write 16.8 / 4.2 on the board. Show how to divide it and how you are actually multiplying the divisor and dividend by 10 before dividing.

4. Assign problems 1 through 4 on p. 174 to students one at a time so teacher can monitor and check their progress.
5. Assign worksheet for practice.
   a. Have students estimate answer.
   b. Allow students to use calculators to find the actual answer.
6. Assign p. 175 (13-37) for homework.

EXTENSION: Students use calculators to write five division problems containing decimals. These can be collected by the teacher and redistributed to give students more practice in solving these problems.

Changing Fractions to Decimals

OBJECTIVE: To write fractions as decimals.

MATERIALS: Calculators, HBJ textbook, overhead projector, acetate sheets, markers

PROCEDURES:

1. Discussion
   a. Teacher asks questions such as:
      How is 1/2 written as a decimal?
      What is 1/2 of a dollar? How do you write it?
      How can 1/2 be changed to .50?
   b. Enter 1/2 in your calculator. Push = button. What answer is displayed?
2. Teacher demonstrates 1/2 on overhead as students observe. Remind students that the / in 1/2 means divide.
3. Repeat steps 1 and 2 using the fraction 1/4.
4. Assign students p. 179 (1-6) to do for practice.
   a. First let them estimate the answer.
   b. Then let them work it using pencil and paper.
   c. Allow them to check it using their calculators.

5. Assign p. 179 (13-24) for homework using the same procedures in step 4 above.

Perimeter - Part I

OBJECTIVE: To calculate the perimeter of a figure in metric units.

MATERIALS: Meter sticks, metric rulers, HBJ textbook, HBJ worksheet (p. 63), and calculators

PROCEDURES:

1. Discuss what perimeter means and how it is used. (Examples: wallpapering, putting up borders or molding, picture frames, etc.).
2. Have students find the perimeter of their desktops in centimeters. They may use calculators for their computation.
3. Group the students in pairs.
   a. Assign each pair an item for which they will have to find the perimeter. These items include the chalkboard, floor, bulletin board, window, door, poster, textbook, etc. Allow them to use calculators.
   b. Discuss results as a group.
4. Assign worksheet for practice with calculators. Discuss answers when finished.
5. Assign p. 195 in textbook for homework.

Perimeter - Part II

OBJECTIVE: To construct and calculate the perimeter of a figure in metric units.

MATERIALS: metric rulers, calculators, and HBJ textbooks

PROCEDURES:

1. Check homework from lesson, Perimeter - Part I. Answer any questions that may have been formulated.
2. Have students draw a 3- and a 4-sided figure. The sides must be in centimeters. Once these are drawn, allow students to swap papers, measure the sides of the drawn figures, and find the perimeters. Calculators are used.
3. Share drawings with the whole class. Assign students to construct ten drawings for homework using any numbers they wish for the measurements. Have students to write the answers on a separate sheet of paper. Tomorrow they will swap papers and find the perimeters using their calculators.

# APPENDIX C

# STATISTICAL DATA

Mathematical Achievement

| Group I-Control | Group II-Experimental |
|---|---|
| $n_1=16$ | $n_2=19$ |
| $\overline{x}_1=10$ | $\overline{x}_2=10.105$ |
| $s_1=7.92$ | $s_2=8.704$ |
| $s^2_1=62.67$ | $s^2_2=75.766$ |

$$t = \frac{\overline{x}_1 - \overline{x}_2}{\sqrt{\left(\frac{(n_1-1)s^2_1+(n_2-1)s^2_2}{n_1+n_2-2}\right)\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}}$$

$$t = \frac{10 - 10.105}{\sqrt{\left(\frac{(16-1)62.67 + (19-1)75.766}{16+19-2}\right)\left(\frac{1}{16}+\frac{1}{19}\right)}}$$

$$t = \frac{.105}{\sqrt{\frac{((15)62.67+(18)75.766)(.0625+.0526)}{35-2}}}$$

$$t = \frac{.105}{\sqrt{\frac{(940.05+1363.788)(.115)}{33}}} = \frac{.105}{\sqrt{\frac{2303.838(.115)}{33}}}$$

$$t = \frac{.105}{\sqrt{69.813(.115)}} = \frac{.105}{\sqrt{8.03}} = \frac{.105}{2.83} = .0371$$

$t_{.05,33} = 2.035$

Since .0371<2.035, the $H_o$ is accepted.

Attitude Survey

| Group I-Control | Group II-Experimental |
|---|---|
| $n_1=16$ | $n_2=19$ |
| $\bar{x}_1=.9375$ | $\bar{x}_2=-1.63$ |
| $s_1=3.2755$ | $s_2=3.06$ |
| $s^2_1=10.729$ | $s^2_2=9.36$ |

$$t = \frac{.9375 - (-1.63)}{\sqrt{\left(\frac{(16-1)10.729+(19-1)9.36}{16 + 19 - 2}\right)\left(\frac{1}{16} + \frac{1}{19}\right)}}$$

$$t = \frac{2.5675}{\sqrt{\frac{((15)10.729+(18)9.36)(.0625+.526)}{35 - 2}}}$$

$$t = \frac{2.5675}{\sqrt{\frac{(160.935+168.48)(.1151)}{33}}} = \frac{2.5675}{\sqrt{\frac{329.415(.1151)}{33}}}$$

$$t = \frac{2.5675}{\sqrt{9.9822(.1151)}} = \frac{2.5675}{\sqrt{1.1489}} = \frac{2.5675}{1.07189} = 2.3953$$

$t_{.05,33} = 2.035$

Since $2.3953>2.035$, the $H_o$ is rejected.

APPENDIX D

SAMPLE

Control Group - Achievement

| Pretest | Posttest | Gain Score |
|---|---|---|
| 19 | 23 | 4 |
| 25 | 48 | 23 |
| 16 | 28 | 12 |
| 5 | 15 | 10 |
| 18 | 39 | 21 |
| 15 | 21 | 6 |
| 9 | 35 | 26 |
| 26 | 36 | 10 |
| 18 | 25 | 7 |
| 5 | 17 | 12 |
| 23 | 30 | 7 |
| 17 | 16 | -1 |
| 7 | 22 | 15 |
| 10 | 11 | 1 |
| 23 | 25 | 2 |
| 12 | 17 | 5 |
| 16 | -- | -- |
| 264 | 408 | 160 |
| $\bar{x}$ = 15.53 | $\bar{x}$ = 25.5 | $\bar{x}$ = 10 |

Experimental Group - Achievement

| Pretest | Posttest | Gain Score |
|---|---|---|
| 10 | 16 | 6 |
| 7 | 25 | 18 |
| 7 | 25 | 18 |
| 12 | 23 | 11 |
| 13 | 28 | 15 |
| 29 | 35 | 6 |
| 18 | 8 | -10 |
| 19 | 24 | 5 |
| 9 | 39 | 30 |
| 17 | 29 | 12 |
| 13 | 19 | 6 |
| 18 | 20 | 2 |
| 9 | 20 | 11 |
| 14 | 23 | 9 |
| 3 | 10 | 7 |
| 14 | 16 | 2 |
| 9 | 23 | 14 |
| 15 | 22 | 7 |
| 32 | -- | -- |
| 12 | -- | -- |
| 293 | 441 | 192 |
| $\overline{x}$ = 13.95 | $\overline{x}$ = 23.21 | $\overline{x}$ = 10.105 |

Control Group - Attitude

| Pretest | Posttest | Gain Score |
|---|---|---|
| 31 | 32 | 1 |
| 28 | 26 | -2 |
| 25 | 31 | 6 |
| 22 | 25 | 3 |
| 29 | 30 | 1 |
| 26 | 29 | 3 |
| 29 | 30 | 1 |
| 34 | 30 | -4 |
| 26 | 28 | 2 |
| 31 | 29 | -2 |
| 32 | 31 | -1 |
| 33 | 31 | -2 |
| 23 | 31 | 8 |
| 27 | 25 | -2 |
| 24 | 28 | 4 |
| 29 | 28 | -1 |
| 25 | == | == |
| 474 | 464 | 15 |
| $\overline{x}$ = 27.88 | $\overline{x}$ = 29 | $\overline{x}$ = .9375 |

Experimental Group - Attitude

| Pretest | Posttest | Gain Score |
|---|---|---|
| 29 | 28 | -1 |
| 22 | 20 | -2 |
| 28 | 25 | -3 |
| 29 | 28 | -1 |
| 27 | 28 | 1 |
| 24 | 23 | -1 |
| 30 | 24 | -6 |
| 30 | 27 | -3 |
| 28 | 25 | -3 |
| 28 | 30 | 2 |
| 32 | 29 | -3 |
| 35 | 34 | -1 |
| 31 | 29 | -2 |
| 30 | 28 | -2 |
| 27 | 27 | 0 |
| 28 | 33 | 5 |
| 36 | 35 | -1 |
| 29 | 19 | -10 |
| 31 | 31 | 0 |
| 16 | -- | -- |
| 29 | == | == |
| $\bar{x}$ = 28.52 | $\bar{x}$ = 27.526 | $\bar{x}$ = -1.6315 |

Summary of Achievement Posttest Scores

| Posttest Scores | Number of Students |
|---|---|
| 45 - 50 | 1 |
| 40 - 44 | 0 |
| 35 - 39 | 6 |
| 30 - 34 | 1 |
| 25 - 29 | 7 |
| 20 - 24 | 10 |
| 15 - 19 | 7 |
| 10 - 14 | 2 |
| 5 - 9 | 1 |
| 0 - 4 | 0 |